Clatskanie People's Utility District – SCADA System

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Abstract: In 2001, Clatskanie PUD installed a Supervisory Control and Data Acquisition (SCADA) system. The utility previously had no such capability. The system was installed to provide full SCADA capabilities and load-data acquisition in order to comply with the Bonneville Power Administration "SLICE" program and power management needs. "SLICE" load data is communicated to EWEB (Eugene Water and Electric Board) who acts as Clatskanie PUD's Scheduling Agent for "real time" and short-term power management.

The new SCADA system uses dual-licensed radio communications channels. The system provides data acquisition, trending and archiving, alarming and paging, control of reclosers, oil circuit breakers, load tap changers and regulators. A new 11 Mw combustion turbine can be monitored, started and stopped from the PUD office. Set-points for the turbine output can be set from either the PUD office or from EWEB.

The SCADA system uses PLC-based RTUs, a PLC-based communication front-end and a Microsoft® Windows 2000® based master station.

Keywords: conservation voltage regulation (CVR), graphic user interface (GUI), local area network (LAN), operator interface terminal (OIT), programmable logic controller (PLC), remote terminal unit (RTU), select-before-operate" (SBO), supervisory control and data acquisition (SCADA), SLICE

Clatskanie PUD History

Oregon's first operating PUD, Clatskanie People's Utility District (CPUD) celebrated its 60th year of operation on March 11, 2003. It was formed by majority vote of the people in 1940 in order to obtain benefits of lower cost power for the community. The only cost to the taxpayers for forming the District was a two-mill tax levied in 1941, which brought in approximately $4,500. In 1943, revenue bonds totaling $175,000 were issued and the property was purchased from West Coast Power Company. The bonds were retired in 1955, twelve years later. In 1943 service began to the Clatskanie and Quincy areas and has extended though annexation to the communities of Westport, Alston-Mayger and Rainier. In 2002, the District began retail sales to industrial customers outside of the District. The District owns 50% of the 36 MW Western Generation Agency (WGA) cogeneration facility located inside the Wauna paper mill. It began operations in 1997. The District also owns and operates an 11 Mw gas turbine generator, which commenced operations in December 2001. (It was nicknamed "Loki" after one of the major deities in the Norse pantheon connected with mischievousness, fire and magic. He can assume many different shapes, is crafty and malicious and grows progressively more unpleasant.)

Clatskanie People's Utility District (CPUD), is located on the Columbia River between Portland and Astoria. Headquartered in Clatskanie, Oregon, the service territory covers 275 square miles. The system includes four substations, 913 miles of distribution and transmission lines and two generation turbines. A five member Board of Directors, representing individual district areas, oversees CPUD. The District currently employs 26 personnel, led by General Manager Greg Booth.

In 2002 gross revenue was $26,049,890 with 796,691,701 Kwh in retail sales and a peak demand of 87,032 Kw. The District has 4,298 total customers, broken down as follows: industrial and extended industrial--88.0%, general service--3.4%, and residential--8.6%.

Business Case

The District had recognized a need for a SCADA system for some time, and at various times had considered implementing a system. In 1999, it became apparent that the District would be entering into a new type of supply agreement with BPA for the “SLICE” product, and it was decided to proceed with the project. Prior to that decision, the District had only the BPA monthly billing statement, a few equipment operations counters, and paper records of monthly inspections of the substations for data acquisition. In the supervisory control area, the District personnel had to go to the substations and manually read the meters. Then, relying on employees’ collective recollection of system capabilities in varying conditions, they manually operated the system.

Initial Procurement Consideration

CPUD had an engineering study prepared by Pacific Engineering Corporation, of Portland, Oregon to cover the basic requirements of a SCADA system and the particular considerations necessary for the District’s service area. Early on it was determined that communications would be one of the most critical parts of a successful system because the service area is in the Coast range where the mountains come down to meet the Columbia River. The heavily timbered area is characterized by extreme topology. Most outages are related to wind damage from trees. The area has several different telephone companies serving District facilities requiring interconnections between telephone companies. Additionally, reliability during storms and the cost of dedicated phone were considered problematic. The area does not have fiber optics that could be reasonably accessed. These conditions pointed toward the use of lower frequency radio communications. In order to meet a BPA redundancy requirement, it was decided to use two radio frequencies with a telephone dial-up modem as a third level of backup. A radio survey was completed in 2000, and the 150 MHz licensed radio frequency band was selected as providing the best coverage. Initially, a spread spectrum radio band was contemplated. However, during the survey and a subsequent test, it was decided to use the licensed frequency radios.

In 2000 the District began to visit other utilities with similar operating conditions and existing SCADA systems. The District incorporated what they learned from these other utilities into their system. They also invited suppliers to make product presentations and went to see these products at other utilities.

System Requirements

Clatskanie PUD determined several concepts would help them put together an effective system:

1) Dual radio systems were specified with the request. The dual networks were to be set up as one being a High Speed Data Network (HSDN) and the other being the Control Data Network (CDN) along with the telephone modem backup.

   The District selected radios over telephone, fiber or satellite for reasons of reliability and cost. The District’s experience was that telephone circuits often overloaded during emergencies such as storms, flooding, high winds and earthquake with the results that “priority” communications had a hard time getting through. In the geographic area the PUD serves, cell phones have been particularly susceptible. Costs for fiber or satellite communications were considered prohibitive.

2) A single type recloser control would be used in the substations. These would replace a collection of older “dumb” controllers with new Intelligent Electronic Devices (IED), greatly increasing the District’s data gathering capability and easing the connection of the substations. This would also eliminate the need for adding more CT’s and PT’s in the substations.

3) All voltage regulators were to be fitted with new IED controls for the same reason.

4) The District entered into an agreement with Bonneville (BPA) whereby BPA installed repeat relays on their metering equipment. The new substation RTUs would see the same pulse information as BPA, but in “near-real-time” instead of at the end of the month.

5) Programmable Logic Controllers (PLCs) were the favored substation control and RTU platform. Because of their universal adaptability and broad available to ability to interface with various pieces of equipment, they provided for flexible equipment selection and future expansion.

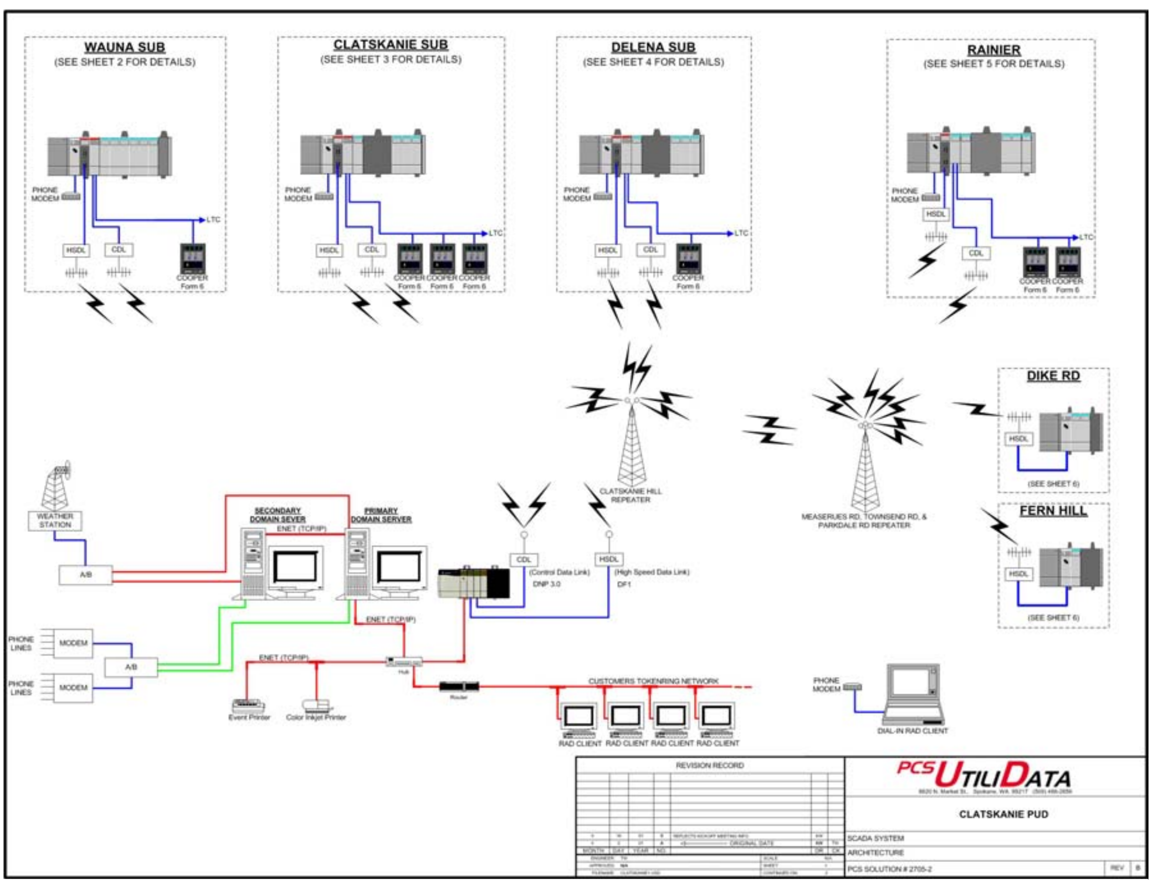
Vendor Selection

The initial studies, surveys and investigations resulted in an RFP that was presented to the General Manager and Board members. The District Board of Directors, in their capacity as a Contract Review Board, approved the staff recommendation that proposals be solicited from a few pre-qualified suppliers rather than an open solicitation. The rationale was that even though there are many vendors for the various component parts of a SCADA system, most focus their efforts in supplying their own equipment, unfortunately sometimes at the expense of the total system performance. For example, a communications system is absolutely essential to SCADA, particularly in the CPUD service area. Yet, since it is not among the products generally manufactured by SCADA vendors, it is often an afterthought in the vendor's efforts or left to the owner to provide. Software vendors have some amazing products which often have integration difficulties with hardware interfaces and field equipment. Many also have reliability issues. On the other hand, the hardware vendors' products often lack the features and sophistication available in good software. Elaborate SCADA specifications are very difficult, slow, and expensive to prepare. Often the specifications are too specific, thereby excluding valid suppliers and resulting in challenges, or they are too broad, resulting in confusion, change orders, and poor project performance.

The Board approved the alternate bidding procedure, and the RFP was sent to three selected suppliers, each of which had successfully provided turnkey SCADA systems in western Oregon and Washington. After careful evaluation by District personnel, PCS UtiliData, of Spokane, Washington was selected to provide the SCADA system.

SCADA System Architecture

Figure 1 shows the overall architecture of the system CPUD purchased. The standard UtiliData™ SCADA system required no modifications to meet the requirements of the procurement specification.



Overall the system consists of a UtiliData™ Master Station which uses a PLC-based communications front-end and redundant server-class PCs that serve as the data collection engines, the graphic user interface (GUI) and the operator interface terminals (OIT.) In the substations, PLC-based UtiliData™ 2202s serve as the RTUs and as the substation automation platforms.

Communications

The procurement specification initially indicated the District's strong preference for dual spread-spectrum radio communication paths. After analyzing the pro's and con's of spread spectrum and the affects of terrain and heavy vegetation, it was decided to used fixed frequency licensed radio networks in the 150-175 MHz range.

The high-speed data network (HSDN) selected uses DF1 protocol, a protocol native to Allen-Bradley PLCs. The control data network (CDN) uses DNP 3.0 protocol. As required by the specification, the HSDN carries a small amount of data and is designed to meet the four (4) second requirement for BPA load aggregation and "SLICE" purposes.

Two radio repeater stations were required for each radio network. The master station is located at the PUD offices in the town of Clatskanie. It is approximately in the center of the system.

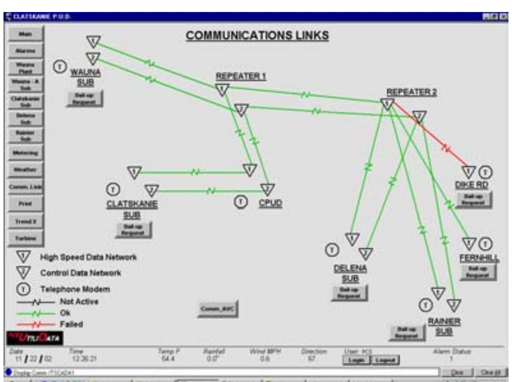


Figure 2 – Communications Screen

Backup telephone communications can be initiated in two ways. It can be initiated at the master station by operator action. Or in the event that the UtiliData™ 2202 detects both radio communications channels are down, it will initiate telephone communications with the master station.

Figure 2 shows the OIT screen for the communications system. This screen shows the operational status of all communications links as well as their alarm status.

Master Station

The UtiliData™ Master Station uses an Allen-Bradley ControlLogix® PLC for front-end communications. It has the capability to support multiple communication channels and modules. In this system, one channel communicates with the OIT PCs via Ethernet. One channel is configured for DF1 to provide high speed communications with substations, and one channel is configured as DNP 3.0 for control data.

Figure 3 - UtiliData™ Master Station

The OIT PCs are server class, running Windows® 2000 Server operating systems. One is set up as the Primary Domain Server (PDS) and the other as the Backup Domain Server (BDS.) RSView 32 serves as the software technology engine for the OIT data collection and GUI applications.

RSView Active Display software is used to provide independent SCADA OIT displays on several different workstations in the District office LAN. Operators can dial in on secure phone lines to access SCADA OIT displays and information using a notebook computer. PC Anywhere® is used to configure standard Microsoft® functionality and to remotely configure the Master Station PCs. Visual Basic is used to provide the telephone dial-in functionality.

A separate Ethernet LAN connects several office computers, a print server and the two OIT PCs. A weather station and specialized software provides weather information to the system and to workstations in the District offices. Current weather data is transferred to the District web page host via FTP, where customers may view it.

Fig. 4 –Weather Screen Web Page

Clatskanie, Delena and Rainer

There are presently four substations, with provision for a fifth substation. Although the PLC-based RTU architectures for Clatskanie, Delena, Rainer and Wauna substations are similar, there are differences in each depending

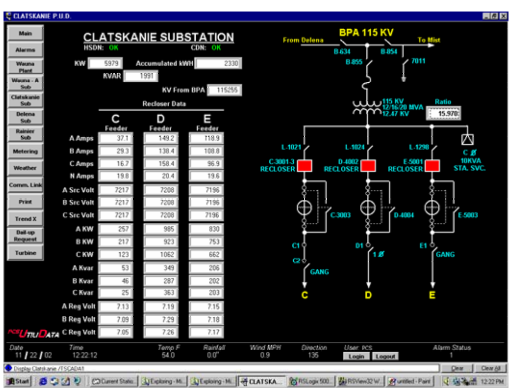


Fig. 5 – Clatskanie Substation Screen

upon the age of the station, the number of distribution feeders and the equipment in the substations.

Clatskanie substation is oldest substation. Because it was constructed in a very constricted location, feeders and equipment are very restricted. Clatskanie substation has three 12Kv feeders, each with three (3) single-phase regulators upgraded with new Siemens MJXL control and DNP 3.0 communications. Each feeder recloser was retrofitted with Cooper Form 6 recloser controls with DNP 3.0 communications. The substation is fed at 115 Kv with a fuse-protected three-phase transformer. It has one BPA revenue-metering point. The PLC-based RTU and the AdaptiVolt™ system are located in enclosures in the substation building.

Delena substation is newer than Clatskanie substation and was constructed using modern substation design standards. Other than the age, design and transformer size, the only other difference is that Delena has only two 12 Kv feeders. The PLC based RTU and the AdaptiVolt™ system are in heated outdoor enclosures because of the restricted size of the building.

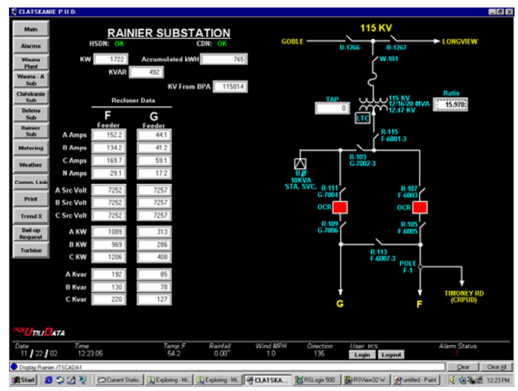


Fig. 6 – Rainier Substation Screen

Rainier substation was purchased from Portland General Electric when Rainier community voted to join the District. It is fed at 115 Kv, has a fused transformer with LTC and has two 12 Kv feeders with oil circuit breakers. There are two metering points within Rainer, one that meters incoming energy from BPA and one at an interface to Columbia River PUD, a neighboring utility. The oil circuit breakers were retrofitted with Cooper Form 6 recloser controls using a circuit breaker adaptor kits.

Wauna Substation

Wauna substation is fed at 230 Kv. It has three transformer banks protected by a combination of remote pilot protection and circuit switchers. Transformer Banks 2 and 3 feed the large paper mill located at the site at 13.8 Kv. Transformer Bank 3 has a Beckwith LTC unit with DNP3.0 communications. Transformer Bank 1 feeds a 12 Kv distribution feeder with three single-phase regulators and a recloser.

The PLC at the existing Western Generation Agency (WGA) cogeneration facility is connected to the RTU via DH-485 LAN. (This connection was made over existing, but unused,

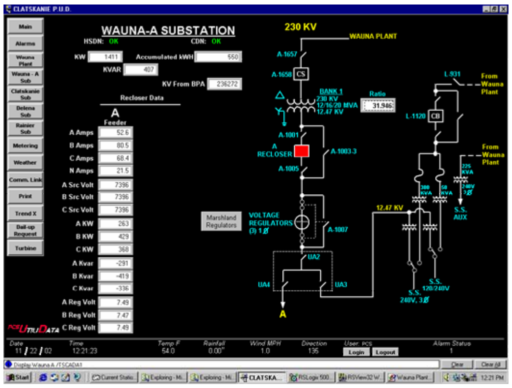


Fig 7 – Wauna Substation Transformer Bank 1 Screen

conductors in a communication cable. Initially, there was some concern this may be exposed to too much electrical noise because of its length and the fact that it ran between the substation and several different buildings in the paper mill. This has not turned out to be a problem.)

The PLC connecting the new combustion turbine to the SCADA system is also connected via LAN to the Wauna RTU. The Wauna RTU and the AdaptiVolt™ system are installed on rack-mounted
panels in the Wauna control building.

Substation LANs

PLC-to-PLC communications within substation

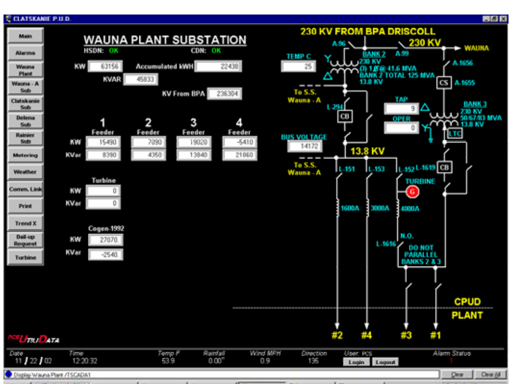


Fig 8 – Wauna Substation Transformer Banks 2 and 3

is via DH-485, a Rockwell Automation LAN protocol, DNP 3.0 over RS-422 multi-drop communications links and Modbus.

At Clatskanie and Delena there are two PLCs, the UtiliData™ 2202 RTU and the UtiliData™ AdaptiVolt™. Communication between these two units is via DH-485.

At Wauna substation, there are PLC-based RTUs at the CT and at the cogeneration plant, in addition to the AdaptiVolt™ PLC and the UtiliData™ 2202. Communications between all Rockwell PLCs at Wauna are via DH-485. The PLC controlling the CT is a GE 90/70, and the communication between it and the SCADA PLC is via Modbus.

The LTC on Transformer Bank 3 at Wauna is a Beckwith control with DNP 3.0 communications capabilities.

All new Cooper Form 6 recloser controls were purchased with DNP3.0 communications, as were the new Siemens MJXL regulator controls installed on the distribution circuits for all District's substations. All substation IED LANs use DNP 3.0 protocol and are connected in RS-422 multi-drop configuration.

Substation Discrete I/O (status and control points)

Discrete inputs to the substation PLC-based RTUs are used for station low-battery alarms, control house temperature alarms, smoke and fire alarms and transformer status and alarms at all substations. At Rainier, discrete inputs are used to determine LTC position. Control outputs are used to raise and lower the LTC. At Wauna, status inputs are used to input all the former BPA SCADA points and annunciator points. Interposing relays were used where contact whetting current was "sinking" rather than "sourcing."

SLICE and BPA Metering Points

Clatskanie PUD participates in the BPA "SLICE" Program. In order to participate, they are required to aggregate load data and communicate to Eugene Water and Electric Board (EWEB).
There are two means of communicating the required data: 1) The WGA cogeneration PLC communicates directly with the EWEB SCADA

master using L&G 8979 protocol, and 2) The Clatskanie PUD SCADA master automatically emails data to EWEB via the Internet.

Thirteen separate metering points are monitored. Except for the new metering point that was installed with the new CT, all were in

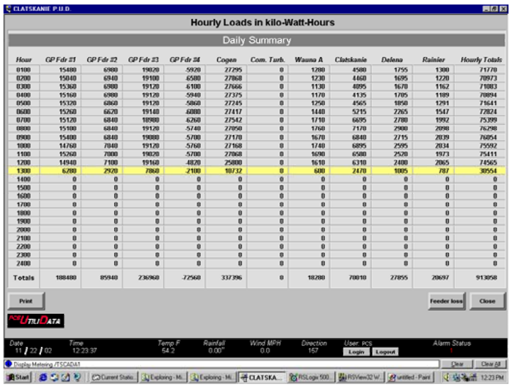


Fig. 9 – Load Data Screen

existence prior to the installation of the new SCADA system. The metering points were under the control of BPA. In order for Clatskanie PUD to meet the BPA "Slice" requirements, both KYZ pulses for Kwh and Kvarh needed to be accumulated by the SCADA system. Instantaneous values for Kw and Kvar were also required. Clatskanie contracted with BPA to install repeater relays to isolate the KYZ and analog signals from the SCADA system. KYZ pulse data is input into PLC digital inputs, and the analog data is input into PLC analog inputs.

Three of the metering points are inter-ties to a neighboring utility. The Timony Road metering point is located within the Rainier substation and metering data is input to the Rainier RTU. The Dike Road and Fernhill Road metering points are located at remote points. Separate PLC-based RTUs collect the metering data and communicate via the HSDN directly with the SCADA master.

Additional Features

All reclosers, regulators and LTCs can be operated from the SCADA master or from specified OITs that have the Active Display software. Password protection is standard and all operation requires "Select-Before-Operate" (SBO). SBO is a critical control feature for the safety of operating crews in the field.

The SCADA alarm system allows different priority alarms. It includes both voice and e-mail text paging. Alarms can be acknowledged and/or cleared from any of the OITs. (The system has the capability to mask nuisance

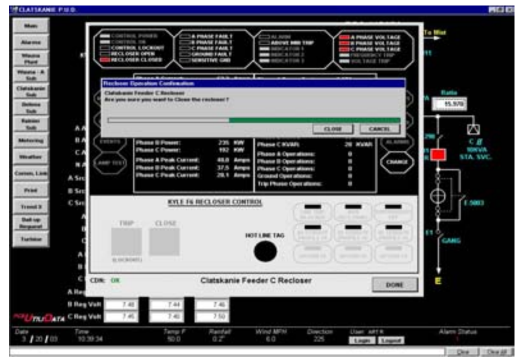


Fig. 10 – Recloser SBO Pop-up Screen

alarms; however, during startup this was not implemented and "alarm storms" during commissioning were somewhat irritating to District personnel.)

The system stores archive data on the SCADA master PCs. Data can also be stored on the network as set up. Each RTU can store critical operational data up to 24 hours in case of a total communications failure.

It is possible to remotely change the configuration of the PLC-based RTU at each substation. This requires having the configuration software and the telephone number and having the key lock protection in the non-protected position. This feature was extremely helpful in the commissioning phase and can be used if upgrades are required.

Installation, Start-up and Commissioning

The installation of the new SCADA system was essentially a turn-key proposition with some pole and substation labor furnished by the District. PCS UtiliData provided all the SCADA equipment and software. Their electrical subcontractor, Power City Electric, installed all Master Station equipment. At the substations, the contractor installed the RTUs and communications cables and connected all IEDs and status points.

The dual-radio system antennae and the repeater stations were installed by the radio vendor, who also commissioned the two systems. CPUD assisted the radio vendor during site surveys, installation and commissioning of the radio system. They also installed the new recloser and regulator controls and provided the new room at the District office for the master station.

Wauna Combustion Turbine

The new 11 Mw combustion turbine (CT) installed at Wauna can be controlled from the SCADA system. A PLC is used to interface the CT control system (furnished by the turbine vendor) to the SCADA system. Modbus is the

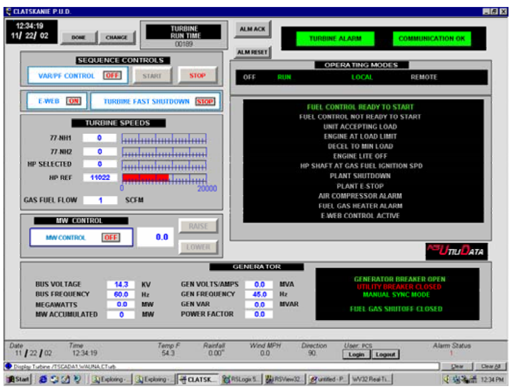


Fig. 11- Combustion Turbine Screen

protocol used for communications with the CT control system. The PLC is connected to the Wauna RTU via the DH-485 LAN in the substation. From the SCADA master screen, the power output of the CT may be viewed, started, stopped and set. The system is also set to allow EWEB to start, stop and set the power output of the CT via the L&G 8979 link through the cogeneration PLC.

During initial start-up and commissioning there was an explosion and fire that resulted in significant damage and much rework. No people were injured but the CT earned the name 'Loki' as a result of the incident.

Adaptive Voltage Control

In late 2001, BPA approved an application for Conservation and Renewable Discount funding for AdaptiVolt™ based Conservation Voltage Regulation at Clatskanie, Delena and Wauna substations. The District decided against installing AdaptiVolt™ at Rainier because of the potential inter-ties to Columbia PUD and the fact that Rainier was an LTC transformer. BPA approved the project as a "Demonstration Project."

The AdaptiVolt™ system monitors real-time voltages at the end of the distribution lines and controls the voltage regulators in the substation. The distribution feeder at Wauna also has a mid-line regulator controlled by AdaptiVolt™.

End-of-line voltages are modulated to the lowest levels consistent with good operation of customer equipment, regulatory agency directives, utility practices and electrical standards. Significant energy conservation is obtained when voltages are operated in the lower half of the allowable voltage range rather than in the upper half of the range.

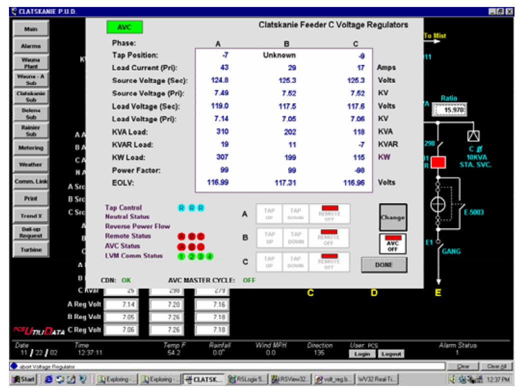


Fig. 12 – Regulator and AdaptiVolt™ Screen

AdaptiVolt™ at each substation can be turned on and off at the SCADA master. Voltage data, regulator operational data and communication status is displayed.

The AdaptiVolt™ systems were commissioned during November-December of 2002. As a "Demonstration Project," all of the systems are scheduled to be run in a test mode for one year. The testing consists of operating one day on and one day off. Interval data consisting of Kwh, Kvarh, Bus Voltage and End-of-line voltages are being collected to review and analyze the actual energy conservation being obtained. Reports will be published at the end of the test year.

Biographies

Art Robare, is a native of Mariposa, California. He served four years in the US Navy as an Electronics Technician. After leaving the Navy, he worked in industry for five years before returning to school. He graduated from the University of Nevada, Reno in 1973 with a BSEE. The next five years were spent working for the Puget Sound Naval Shipyard on shipboard power and control. In 1979 Robare went to work for Cascade Steel in McMinnville, Oregon as Plant Electrical Engineer, where he was advanced to Superintendent of Maintenance & Engineering, Operations Manager, and Director of Special Projects. In 1992 he went to work for McMinnville Water & Light as Engineering Manager. Robare joined Clatskanie PUD as Operations & Engineering Manager in 1999. He is a Registered Engineer in both Oregon and Washington, and he has been a member of IEEE since 1976.

Tom Wilson, Senior Member IEEE, is a native of Spokane, Washington. After serving in the US Navy as an Electricians Mate, he earned his BSEE from Washington State University in 1971. While working as a Substation Operations Engineer at Pacific Gas and Electric Company, he attended the University of Santa Clara studying MSEE courses. In 1982 he earned his MBA from Gonzaga University. Wilson worked as an Electrical Engineer for Kaiser Aluminum and Chemical Corporation and as an Industrial Control Application Engineer for Reliance Electric. Wilson is the founder and president of PCS UtiliData, a Spokane, Washington based control system integration firm specializing in substation and utility automation and automated energy conservation for electric utilities. He has been active in the IEEE and is a member of the Western Power Delivery Automation Conference Program Committee.

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